

Fast, Parallel, High-Quality Voronoi Mesh Generator, Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

In this work we propose to further develop and demonstrate a mesh generation approach based on **clipped Voronoi diagrams**. This approach to mesh generation has the potential to significantly improve performance and robustness, while retaining important elements of high quality meshes including boundary alignment, stretching, and element regularity. Clipped Voronoi diagrams also automatically de-feature the underlying geometry at the local resolution of the generating points, and can thus significantly impact the problem of CAD clean-up and defeaturing.

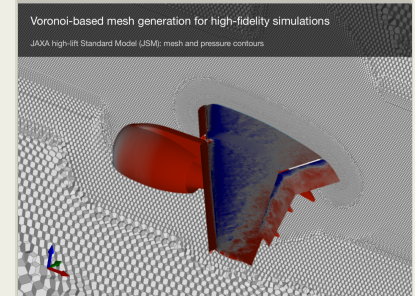
The mathematical properties of Voronoi diagrams enable highly scalable mesh generation, since the global mesh is uniquely defined yet each individual cell can be constructed with only local information. Importantly the Voronoi paradigm reduces the problem of mesh generation to the much simpler problem of specifying the locations (point cloud) where the solution will be sampled. The actual mesh (volumes, faces, topology, neighbor connectivity) is simply a unique mathematical consequence of this choice. This dramatically simplifies control over local mesh resolution - an important consideration for automation and high-fidelity simulations. Additionally, the discretization of the boundary surface is independent from the near-boundary mesh resolution, allowing arbitrary coarsening or refinement relative to the local surface length scales. The impact of leveraging these benefits in mesh generation will be a dramatic reduction in the time and human interaction required to generate quality meshes for high-fidelity applications.

Understanding solution sensitivity to the point cloud parameters is the technical objective of the current proposal. We will assess solution sensitivity with respect to three different aspects related to the spatial arrangement of the point cloud. The cases investigated are relevant building blocks for aerodynamic problems of interest, i.e., the NASA Juncture Flow experiments.

Anticipated Benefits

Stitch's high-quality Voronoi meshes would benefit any solver utilizing polyhedral elements. Phase II will produce tools, specifically tetrahedral meshing and quadratures on regular polyhedra, that could benefit NASA's FEM solver, FUN3D, as well as its DG and spectral-element solver, eddy. Charles, Cascade's massively parallel, low-dissipation multi-physics LES solver, leverages the properties of Voronoi meshes for accurate multi-physics, multiscale LES simulations could serve NASA engineers.

Consumers utilizing Charles (e.g., gas-turbine sector of General Electric, aerothermodynamics research at Honda, and fuel-injection research at Bosch) would benefit from the mesh efficiencies gained through our Phase I. Through demonstrations of mesh/solution quality, speed, scalability and workflow ease, we aim to increase the pool of consumers by making the push from a research and analysis framework to a true design tool.



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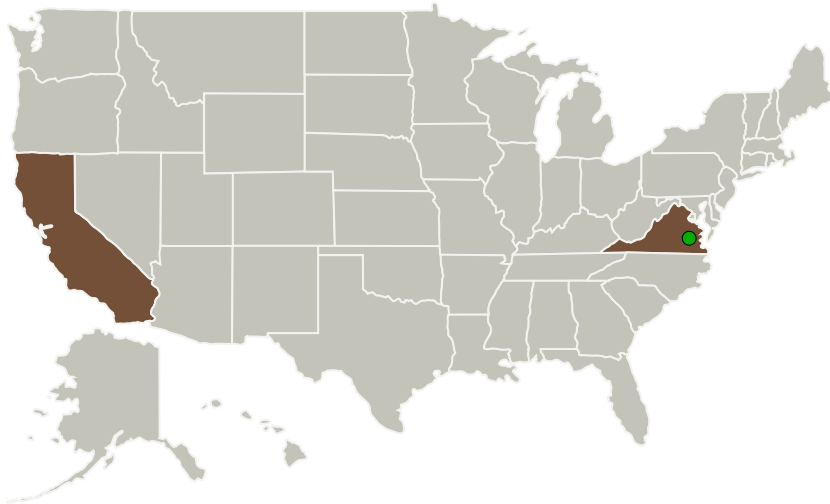
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
CASCADE Technologies, Inc.	Lead Organization	Industry	Palo Alto, California
● Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations

California	Virginia
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Project Transitions

**July 2018:** Project Start**February 2019:** Closed out**Closeout Documentation:**

- Final Summary Chart(<https://techport.nasa.gov/file/141049>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

CASCADE Technologies, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

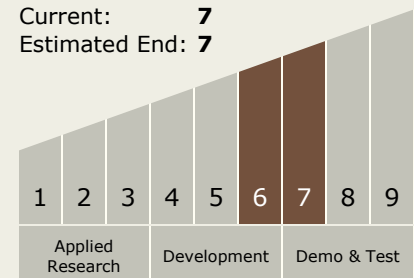
Carlos Torrez

Principal Investigator:

Michael A Emory

Technology Maturity (TRL)

Start: 6
 Current: 7
 Estimated End: 7

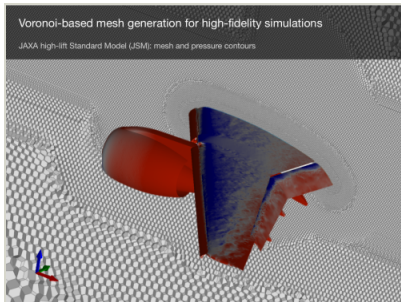


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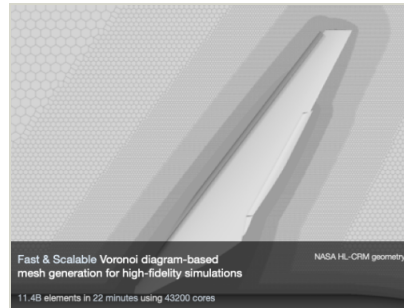


Images



Briefing Chart Image

Fast, Parallel, High-Quality Voronoi Mesh Generator, Phase I
(<https://techport.nasa.gov/image/135301>)



Final Summary Chart Image

Fast, Parallel, High-Quality Voronoi Mesh Generator, Phase I
(<https://techport.nasa.gov/image/132222>)

Technology Areas

Primary:

- TX15 Flight Vehicle Systems
 - └ TX15.1 Aerosciences
 - └ TX15.1.1 Aerodynamics

Target Destination

Earth